Express Mail No. EV340929494US
Date of Deposit. September 8, 2004

Our Case No. 11336/616

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
PIERRE ZAKARAUSKAS	
Serial No. 09/375,309	Examiner Angela A. Armstrong
Filing Date: August 16, 1999	Group Art Unit No. 2654
For NOISY ACOUSTIC SIGNAL ENHANCEMENT	

APPEAL BRIEF

Mail Stop Appeal Brief – Patent
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Assignee appeals from the decision of the examiner to the Board of Patent Appeals and Interferences in the above-identified patent application. Assignee has filed this Appeal Brief in triplicate and paid the appropriate fee in accordance with 37 CFR §1.192 and §1.17(c).

Real Party in Interest

The real party in interest is Harman Becker Automotive Systems - Wavemakers, Inc, a corporation having a place of business in Vancouver, British Columbia, Canada.

Related Appeals and Interferences

The Assignee filed a Notice of Appeal in Application Serial No. 09/385,975 ("the classification application") on June 10, 2004. The Assignee filed the appeal brief for the

classification application on September 8, 2004. The appeal in the classification application may have a bearing on the Board's decision in this appeal.

Status of Claims

1. Claims 1, 3, 5, and 7-23 are pending.
2. Claims 1, 3, 5, and 7-9 have been rejected multiple times.
3. Claims 1, 3, 5, 7, and 7-23 were finally rejected on Feb. 13, 2004.
4. The Assignee appeals the decision of the examiner finally rejecting claims 1, 3, 5, and 7-23.

Status of Amendments

All amendments have been entered and the Assignee has presented no amendments subsequent to the Feb. 13, 2004 final rejection.

Summary of Invention

The claims are directed to a system that enhances acoustic signals concealed in noise. The system transforms a digitized acoustic signal to a time-frequency representation. For each interval of the time-frequency representation containing signal content, the system performs a signal-to-noise ratio weighted comparison of the time-frequency representation to multiple time-frequency spectrogram templates in a signal model. (specification pages 8, 12, Figure 2).

The spectrogram templates may represent low noise signal models. The models may provide frequency component magnitudes over time and over frequency. In the signal model, a spectrogram template that is similar to the transformed input signal provides a low-noise estimate of the signal content in the input signal. The potentially noisy input signal may be replaced with a low-noise output signal. The output signal may be formed as a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template. The weighting ensures that signal bands that carry significant noise are primarily replaced with content from the matching (lower-noise) spectrogram. (specification page 12, Figure 2).

The signal-to-noise ratio weighted mix, 'C', may be determined according to: C = w * P + (wmax - w) * T. In that equation, 'w' may represent a signal-to-noise ratio proportional weight, 'wmax' may represent a pre-selected maximum weight, 'P' may represent the time-frequency representation of the input signal, and 'T' may represent the matching spectrogram template. (specification page 12, Figure 2).

Information about the signal content in the input signal may impact the operation of the system. For example, signal strength in the input signal time-frequency representation may be determined. When the signal strength is less than a threshold, the background noise statistics may be updated, rather than attempting to find a matching template based on a weak signal. (specification page 14, Figure 3).

Issues

The issue presented for review is whether claims 1, 3, 5, and 7-23 are unpatentable under §103(a) in view of any combination of the Quatieri article, the Kenyon patent (U.S. Pat. No. 4,843,562), the Liu patent (U.S. Pat. No. 5,680,508), and the Fink patent (U.S. Pat. No. 5,933,801).

Grouping of Claims

Group 1: Claims 1, 3, 5, 10, 11, 13, 15 stand or fall together.
Group 2: Claims 7, 8, 9, 17, 18, 20, and 22 stand or fall together.
Group 3: Claims 12, 14, and 16 stand or fall together.
Group 4: Claims 19, 21, and 23 stand or fall together.

Argument

An obviousness analysis includes an assessment of the scope and content of the prior art. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966). Obviousness is a legal conclusion based on underlying factual inquiries. The factual inquiries include: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences between the claimed invention and the prior art; and (4) objective evidence of nonobviousness. *Graham,* 383 U.S. at 17-18. In addition, a successful assertion that a claim is obvious based on a combination of references requires a suggestion or

motivation to combine the references. *WMS Gaming Inc. v. Int'l Game Tech.*, 184 F.3d 1339, 1355 (Fed. Cir. 1999).

1. The cited references do not teach or suggest an output signal that includes a signal-to-noise ratio weighted mix of an input signal and a matching spectrogram template.

The claims in the first group recite replacing the original digitized acoustic input signal with a low-noise output signal. The claimed low noise-output signal comprises a signal-to-noise ratio weighted mix of the time-frequency representation of the input signal and a matching low-noise spectrogram template.

The combined references disclose a noise reduction system with speech pitch manipulation. Assuming that there is motivation to combine so many different references, the combined noise reduction system does not replace the input signal with a signal-to-noise ratio weighted mix of a spectrogram template and the time-frequency representation of the input signal. The office action asserts that Quatieri discloses such a signal replacement technique. Quatieri does not.

Quatieri attempts to minimize a least squared error between a measured signal y(n) and a signal x(n) generated by a sine-wave model (Equations 4a - 10). Quatieri notes that it may be desirable to retain high energy regions of a spectrum unaltered, but that low noise regions may be replaced with the model (page 824). The combined system teaches a binary approach in which an output signal includes either original signal content, or signal model content.

The combined system does not teach or suggest a signal-to-noise ratio weighted mix between the original signal content and the signal model content, let alone a signal-to-noise ratio weighted mix between a matching spectrogram template and a time-frequency representation of the input signal. The claimed system applies a different technique that provides superior control over the output signal. The claimed technique forms the output signal as a signal-to-noise ratio weighted mix between a matching template and a time-frequency representation of the input signal.

Accordingly, the Assignee respectfully requests the Board to reverse the decision of the Examiner rejecting the claims in Group 1 under §103(a).

2. The cited references do not teach or suggest updating background noise statistics responsive to input signal strength.

The claims in Group 2 also recite replacing the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template. The claims in Group 2 are patentable for at least the same reasons as the claims in Group 1.

In addition, the claims in Group 2 recite determining signal strength in the time-frequency representation. When the signal strength is under a threshold, the system updates a background noise statistic. When the signal strength is greater than the threshold, a matching template may instead be found by performing a signal-to-noise ratio weighted comparison of the time-frequency representation of the input signal against the spectrogram templates.

The asserted combination of references does not teach or suggest the claimed signal strength features. In fact, the final office action fails to identify at all where these features may be found or are suggested in the cited references. In the pending claims of Group 2, the signal strength features allow the inventions to avoid wasting processing time in attempts to find a spectrogram match for a weak signal. Instead, the system may beneficially update noise statistics.

Accordingly, the Assignee respectfully requests that the Board reverse the decision of the Examiner rejecting the claims in Group 2 under §103(a).

3. The cited references do not teach or suggest the claimed signal-to-noise ratio weighted output signal.

As dependent claims from claims in Group 1, the claims in Group 3 also include replacing the digitized acoustic input signal with a low-noise output signal comprising a

signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template. The claims in Group 3 are patentable for at least the same reasons as the claims in Group 1.

In addition, the claims in Group 3 recite that the signal-to-noise ratio weighted mix, C, is determined according to: C = w * P + (wmax - w) * T, where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

The office action asserts that the claimed signal-to-noise ratio weighted mix is obvious in view of the "routine skill in the art." In particular, the office action asserts that the claimed weighted mix follows from the "routine skill in the art" in light of Quatieri's "signal-to-noise ratio weighted mix based on P templates, voicing probability, noise factors, template weights, and B(w) time frequency representations." (Final Office Action, page 5).

As explained above, Quatieri does not disclose a signal-to-noise ratio weighted mix of any signals, let alone a matching spectrogram template and a time-frequency representation of the input signal. Furthermore, there is no teaching or suggestion in the cited references or any combination of the cited references that a signal-to-noise ratio should include the claimed weight, maximum weight, template and signal variables and relationships. Nor does the office action explain where or how the variables and relationships may be found in the "routine skill in the art."

The approach precisely forms the output signal as a signal-to-noise ratio weighted mix between two signal components: a matching template and a time-frequency representation of the input signal. The approach also carefully limits the degree to which each component may contribute to the output signal by employing a maximum weighting parameter. The claimed approach is different than the asserted combination of references that lacks such precise control over output signal formation.

Accordingly, the Assignee respectfully requests that the Board reverse the decision of the Examiner rejecting the claims in Group 3 under §103(a).

4. The cited references do not teach or suggest the claimed signal-to-noise ratio weighted output signal.

The Group 4 claims are dependent from claims in Group 2. The Group 4 claims therefore also include the signal strength and signal-to-noise ratio weighted mix features discussed above with respect to the Group 2 claims. The claims in Group 4 are patentable for at least the same reasons as the claims in Group 2. In addition, the claims in Group 4 recite that the signal-to-noise ratio weighted mix, C, is determined according to: $C = w * P + (wmax - w) * T$. The claims in Group 4 also are patentable for at least the same reasons as the claims in Group 3.

Accordingly, the Assignee respectfully requests the Board to reverse the decision of the Examiner rejecting the claims in Group 4 under §103(a).

Conclusion

Assignee respectfully submits that the inventions defined in claims 1, 3, 5, and 7-23 are unobvious in view of any combination of the cited references. The Assignee therefore requests reversal of the §103(a) rejection asserted in the final office action.

Respectfully submitted,

John F. Nethery
Registration No. 42,928
Agent for Assignee

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, ILLINOIS 60610
(312) 321-4200

Claim Appendix - Pending claims 1, 3, 5, 7-23

1. A method for enhancing acoustic signal buried in noise within a digitized acoustic input signal, including:

(a) transforming the digitized acoustic input signal to a time-frequency representation;

(b) detecting transient duration in conjunction with estimating a background noise level in the time-frequency representation;

(c) for each interval of the time-frequency representation containing significant signal levels, performing a signal-to-noise ratio weighted comparison of the time-frequency representation of such interval against a plurality of time-frequency spectrogram templates in a signal model and determining a matching spectrogram template in the signal model that best matches the time-frequency representation of such interval; and

(d) replacing the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

3. A system for enhancing acoustic signal buried in noise within a digitized acoustic input signal, including:

(a) means for transforming the digitized acoustic input signal to a time-frequency representation;

(b) means for detecting transient duration in conjunction with estimating a background noise level in the time-frequency representation;

(c) for each interval of the time-frequency representation containing significant signal levels, means for performing a signal-to-noise ratio weighted comparison of the time-frequency representation of such interval against a plurality of time-frequency spectrogram templates in a signal model and determining a matching spectrogram template in the signal model that best matches the time-frequency representation of such interval; and

(d) means for replacing the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

5. A computer program, stored on a computer-readable medium, for enhancing acoustic signal buried in noise within a digitized acoustic input signal, the computer program comprising instructions for causing a computer to:

(a) transform the digitized acoustic input signal to a time-frequency representation;

(b) detect transient duration in conjunction with estimating a background noise level in the time-frequency representation;

(c) for each interval of the time-frequency representation containing significant signal levels, perform a signal-to-noise ratio weighted comparison of the time-frequency representation of such interval against a plurality of time-frequency spectrogram templates in a signal model and determine a matching spectrogram template in the signal model that best matches the time-frequency representation of such interval; and

(d) replace the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

7. A method for enhancing acoustic signal buried in noise within a digitized acoustic input signal, including:

(a) transforming the digitized acoustic input signal to a time-frequency representation;

(c) detecting transient duration in conjunction with estimating background noise and including long transients without signal content and background noise between transients in such estimating;

determining signal strength in the time-frequency representation;

updating a background noise statistic based on the time-frequency representation when the signal strength is under a pre-selected threshold;

(e) performing a signal-to-noise ratio weighted comparison, when the signal strength is greater than the pre-selected threshold, of the time-frequency representation against a plurality of time-frequency spectrogram templates in a signal model;

(f) determining a matching spectrogram template in the signal model that best matches such representation; and

(g) replacing the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

8. A system for enhancing acoustic signal buried in noise within a digitized acoustic input signal, including:

(a) means for transforming the digitized acoustic input signal to a time-frequency representation;

(c) means for detecting transient duration in conjunction with estimating background noise and including long transients without signal content and background noise between transients in such estimating;

(d) means for determining signal strength in the time-frequency representation;

(e) means for updating a background noise statistic based on the time-frequency representation when the signal strength is under a pre-selected threshold;

(g) means for performing a signal-to-noise ratio weighted comparison, when the signal strength is greater than the pre-selected threshold, of the time-frequency representation against a plurality of time-frequency spectrogram templates in a signal model;

(h) means for determining a matching spectrogram template in the signal model that best matches such representation; and

(i) means for replacing the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

9. A computer program, stored on a computer-readable medium, for enhancing acoustic signal buried in noise within a digitized acoustic input signal, the computer program comprising instructions for causing a computer to:

(a) transform the digitized acoustic input signal to a time-frequency representation;

(c) detect transient duration in conjunction with estimating background noise and including long transients without signal content and background noise between transients in such estimating;

determine signal strength in the time-frequency representation;

update a background noise statistic based on the time-frequency representation, when the signal strength is under a pre-selected threshold;

(d) rescale the time-frequency representation of the estimated background noise;

(e) perform a signal-to-noise ratio weighted comparison, when the signal strength is greater than the pre-selected threshold, of the time-frequency representation against a plurality of time-frequency spectrogram templates in a signal model;

(f) determine a matching spectrogram template in the signal model that best matches such representation; and

(g) replace the digitized acoustic input signal with a low-noise output signal comprising a signal-to-noise ratio weighted mix of the time-frequency representation and the matching spectrogram template.

10. The method of claim 1, where the low-noise output signal comprises a low-noise spectrogram.

11. The method of claim 10, further comprising synthesizing a time series output from the low-noise spectrogram.

12. The method of claim 1, where the signal-to-noise ratio weighted mix, C, is determined according to:

$$C = w*P + (wmax - w)*T,$$

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

13. The system of claim 3, where the low-noise output signal comprises a low-noise spectrogram, and further comprising means for synthesizing a time series output as a sum of a harmonic part and a non-harmonic part derived from the low-noise spectrogram.

14. The system of claim 3, where the signal-to-noise ratio weighted mix, C, is determined according to:

$$C = w * P + (wmax - w) * T,$$

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

15. The computer-readable medium of claim 5, where the low-noise output signal comprises a low-noise spectrogram, and where the instructions further cause the computer to synthesize a time series output from the low-noise spectrogram.

16. The computer-readable medium of claim 5, where the signal-to-noise ratio weighted mix, C, is determined according to:

$$C = w * P + (wmax - w) * T,$$

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

17. The method of claim 7, where the low-noise output signal comprises a low-noise spectrogram.

18. The method of claim 17, further comprising synthesizing a time series output from the low-noise spectrogram.

19. The method of claim 7, where the signal-to-noise ratio weighted mix, C, is determined according to:

$$C = w*P + (wmax - w)*T,$$

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

20. The system of claim 8, where the low-noise output signal is a low-noise spectrogram, and further comprising means for synthesizing a time series output from the low-noise spectrogram.

21. The system of claim 8, where the signal-to-noise ratio weighted mix, C, is determined according to:

$$C = w * P + (wmax - w) * T,$$

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.

22. The computer-readable medium of claim 9, where the low-noise output signal comprises a low-noise spectrogram, and where the instructions further cause the computer to synthesize a time series output from the low-noise spectrogram.

23. The computer-readable medium of claim 9, where the signal-to-noise ratio weighted mix, C, is determined according to:

C = w * P + (wmax - w) * T,

where 'w' comprises a signal-to-noise ratio proportional weight, 'wmax' comprises a pre-selected maximum weight, 'P' comprises the time-frequency representation, and 'T' comprises the matching spectrogram template.